Synthetic Theater of War (STOW)

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Contents

- **ACTD Recap**

- **Federation Description and Statistics**

- **Use of rti-s and Routing Spaces**

- **Distributed Exercise Management (DEM) and MOM**

Goal of the STOW ACTD

Demonstrate the capabilities of high-resolution (platform level) simulation applied to Joint Command and Staff Training and Mission Rehearsal

USACOM STOW ACTD Objectives

- **Higher resolution models**
- **Higher fidelity environmental effects**
- **Intelligence sensor/platform models**
- **Warfighter interfaces through go-to-war systems**
- **Interfaces to actual mission planning system**
- **High quality After Action Review**
- **Rapid scenario database construction**
- **Command forces models to reduce number of role players**
- **Components participate from remote locations via network**

- **Demonstrate HLA-compliant system architecture.**
- **Integrate ADS technologies into a system capable of supporting a JTF level training exercise.**
- **Demonstrate advanced Synthetic Forces capabilities:**
  - **High resolution models to support Joint and combined operations**
  - **Command Forces up to the Bn level**
  - **Re-engineer MODSAF (JointSAF) to take advantage of HLA**
- **Demonstrate advanced Synthetic Environments:**
  - **High resolution terrain**
  - **Realistic environmental effects and battlefield phenomenology**
  - **Dynamic terrain effects**
  - **Interaction of synthetic forces with the terrain, environmental effects and phenomenology**

- Demonstrate high quality AAR capability.

- Demonstrate interfaces between the simulation and go-to-war C4I/mission planning systems.

- Demonstrate ability to rapidly generate a tactical scenario.

- Demonstrate a simulation support infrastructure capable of supporting up to 50,000 entities.

- Transition and transfer STOW technologies to:
  - JCS sponsored and Service-specific simulation programs (e.g. JSIMS, WARSIM, NASM, JSIMS MARITIME Component)
  - Service Simulation Offices (e.g. STRICOM, PMS 450, ESC, Commandant's Warfighting Lab)
 - The United Kingdom

STOW Demonstration Construct
(Show of Force Deterrence)

Technology

- HLA compliant
- ModSAF
- CFOR(Command Forces)
- Terrain Data Base
- Environmental effects
- C4I Interfaces
- Exercise generation
- After Action Review
- ATM multicast network
- Distributed sites

Missions

- Amphibious Operations
- Countermine Operations
- Theater Missile Defense
- Special Operations
- Ground Component
- Air Operations
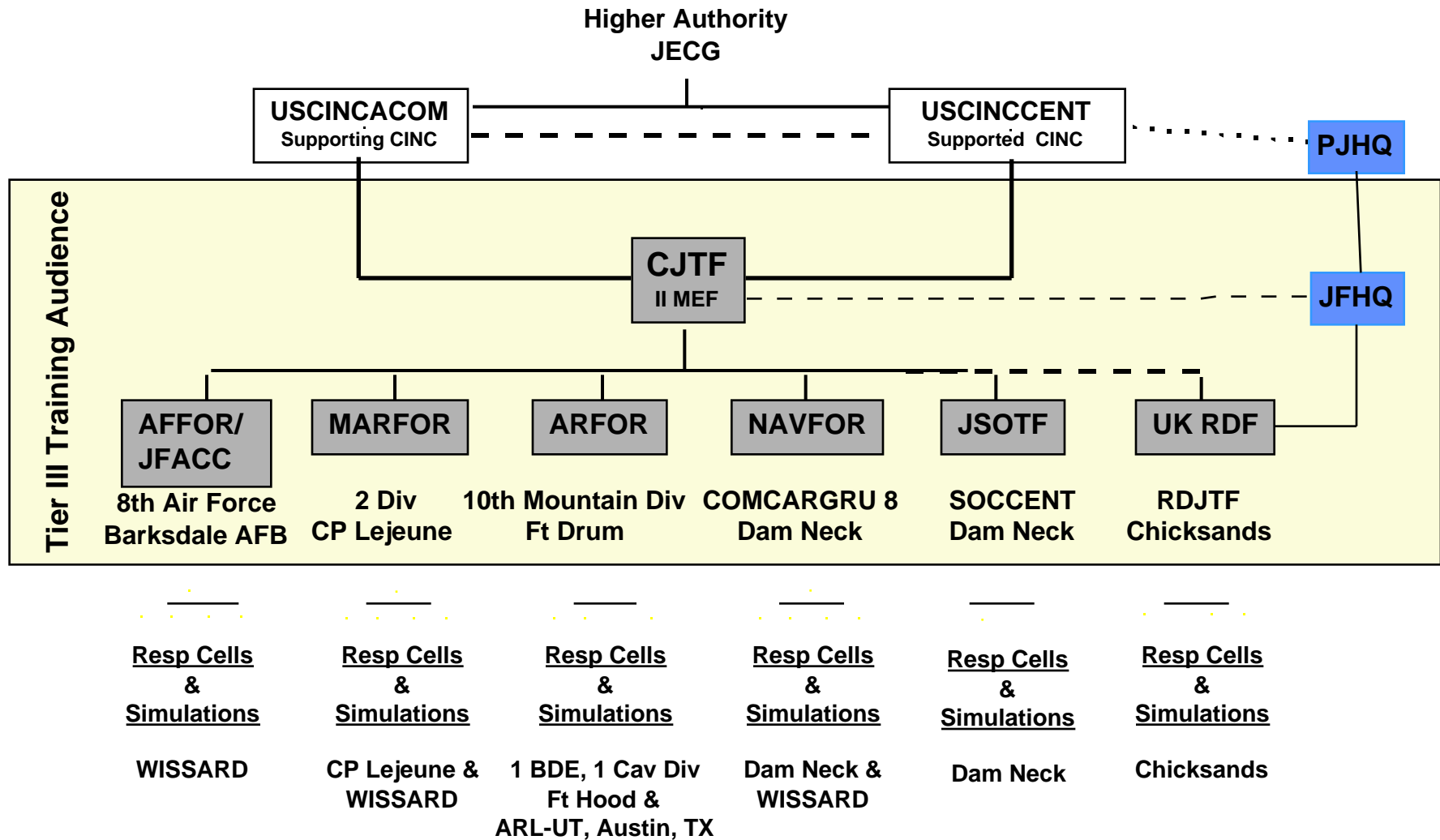- Intelligence
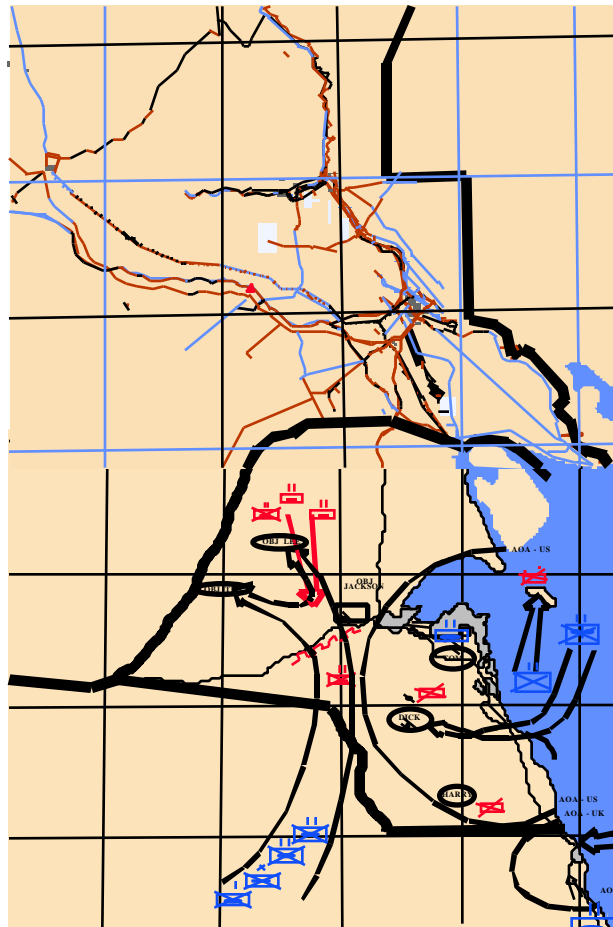
Forces

UK Forces	Air Force Composite Wing	Navy Carrier Battlegroup - Amphib Read Grp - Countermine Aux	Marine Expeditionary Unit	Army Heavy Brigade	OPFOR

STOW Training Audience

Higher Authority
JECG

USCINCACOM		USCINCCENT	PJHQ
Supporting CINC		Supported CINC	

Tier III Training Audience

CJTF
II MEF

JFHQ

AFFOR/ JFACC	MARFOR	ARFOR	NAVFOR	JSOTF	UK RDF
8th Air Force Barksdale AFB	2 Div CP Lejeune	10th Mountain Div Ft Drum	COMCARGRU 8 Dam Neck	SOCCENT Dam Neck	RDJTF Chicksands

Resp Cells & Simulations	Resp Cells & Simulations	Resp Cells & Simulations	Resp Cells & Simulations	Resp Cells & Simulations	Resp Cells & Simulations
WISSARD	CP Lejeune & WISSARD	1 BDE, 1 Cav Div Ft Hood & ARL-UT, Austin, TX	Dam Neck & WISSARD	Dam Neck	Chicksands

STOW 97 ACTD Accomplishments

- Demonstrated that platform level simulation in a high resolution synthetic environment can work reliably and at sufficient scale to drive a JTF or lower level training exercise

- Simulated 4600 platforms (8000 objects) simultaneously using ~500 computers at 5 sites.*

- Successfully demonstrated Company & Battalion CFOR Behaviors

- No Federation-wide or site-wide failures

- No Network outages

- Largest HLA Federation ever demonstrated

* Measured during Full System Test #4

STOW Federation Description & Statistics

- **A very large Federation of exercise support tools, simulations (both synthetic forces and synthetic natural environment), and C4I interfaces**

- **28 Federate types**

- **About 400 Federates; other computers hosted applications that did not have RTI interfaces**

- **5 hardware/OS combinations supported**

  - **SGI/Irix 5.3 and SGI/Irix 6.2**

  - **Sun/SunOS 2.5**

  - **P6/Redhat Linu**

-

The STOW FOM

- **Very flat; basically a DIS FOM**

- **Created without the benefit of the OMDT (schedule issues; learning curve issues); recorded in an MSWord document**

- **Changed some existing interactions, for example:**

  - **Added some parameters to the Fire interaction (formerly known as the Fire PDU) to pass additional data to the Ordnance Server Federate**

  - **Added some new object classes to support the dynamic synthetic natural environment, for example:**

  - **Nominated Environmental Change Notices**

  - **Approved Environmental Change Notices**
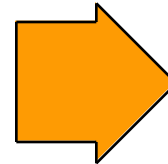
FOM Lessons Learned

- **Shared DIS experience of STOW simulation developers was a big plus; there was not much confusion about the FOM content until we started tuning it for optimization.**

- **Common interface to RTI shared by majority of STOW Federates made FOM (and FED/RID file) configuration management easier.**

- **Tuning the subscriptions and publications happened gradually as we worked through our Full System Tests (FSTs)**

- **In hindsight, we should have strayed farther from the DIS 2.0.4 standard; more customization would likely lead to improved performance of the Federation**

Performance: STOW's Special Challenges
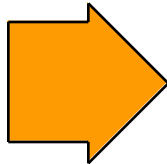
Larger Scale ➡ More Traffic ➡ Higher-performance Network elements
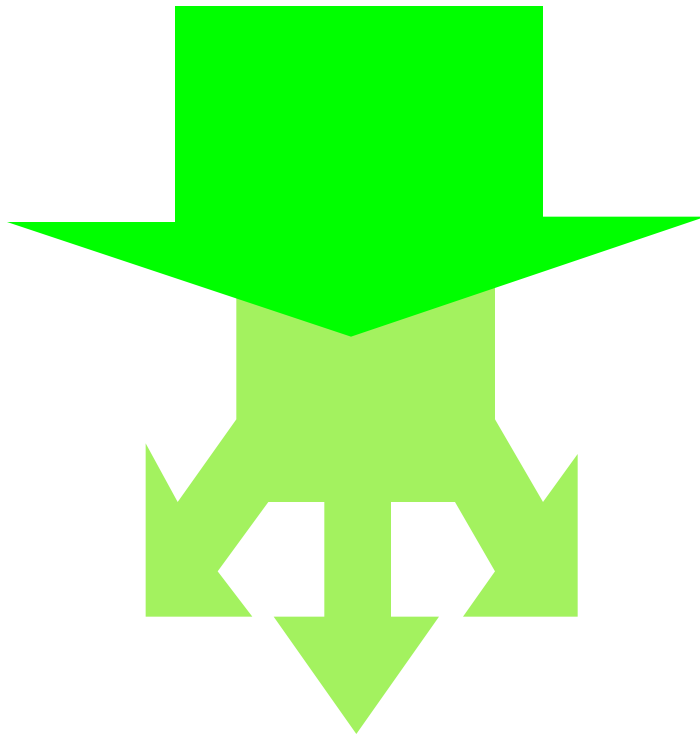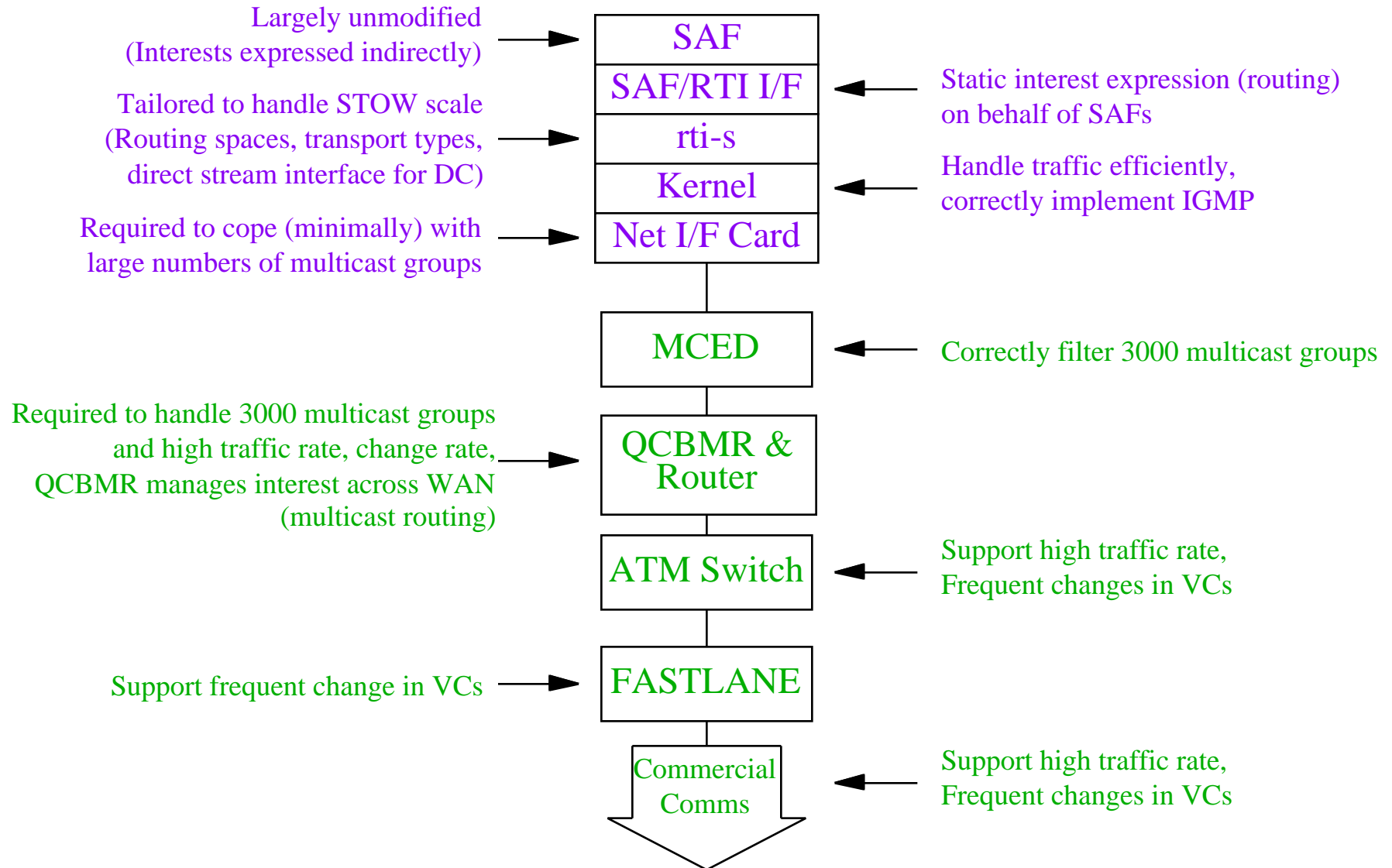
- **Too much data for broadcast -- *interest management* required**

- **Interest management has system-wide implications; when using legacy code, hardware and software changes at all levels are needed**

- **New development needed, both within STOW, and COTS**

  - **Developmental infrastructure does not provide stable platform to run applications (e.g., STOW Federation upgraded through 14**

Use of rti-s Prototype

- **Background**
  - DMSO and DARPA worked jointly to create an early prototype of the RTI that aspired to meet the high bandwidth and low latency data exchange requirements of the STOW ACTD.
  - Software development was done by LL/MIT team.
  - rti-s design and implementation focused on data distribution management (DDM) services.
  - rti-s prototype did not support all services in I/F specification due to cost and schedule constraints.
  - Lessons learned and techniques from rti-s implementation have been merged back into the RTI 1.3 product

Basic Implementation

Largely unmodified
(Interests expressed indirectly) ⟶ **SAF**

SAF/RTI I/F ⟵ Static interest expression (routing) on behalf of SAFs

Tailored to handle STOW scale
(Routing spaces, transport types,
direct stream interface for DC) ⟶ **rti-s**

Kernel ⟵ Handle traffic efficiently, correctly implement IGMP

Required to cope (minimally) with
large numbers of multicast groups ⟶ **Net I/F Card**

MCED ⟵ Correctly filter 3000 multicast groups

Required to handle 3000 multicast groups
and high traffic rate, change rate,
QCBMR manages interest across WAN
(multicast routing) ⟶ **QCBMR & Router**

ATM Switch ⟵ Support high traffic rate, Frequent changes in VCs

Support frequent change in VCs ⟶ **FASTLANE**

Commercial Comms ⟵ Support high traffic rate, Frequent changes in VCs

STOW Routing Spaces

- **Data Distribution Management (DDM) was a critical requirement for STOW in order to...**
  - Keep traffic levels across the WAN between sites within acceptable (affordable) levels
  - Keep quantity of data arriving at each computer within capacity of CPU and NIC to handle
- **STOW's underlying DDM mechanisms were selected and first tested under RITN program before advent of HLA**
- **Concept of *Routing Space* was added when building rti-s in order to achieve compliance with requirement that rti be "stateless" and have no built-in knowledge of FOM internals.**

STOW Routing Spaces (Continued)

- **Routing spaces added depth to STOW FOM**
  - **E.g., entity -> ground -> highres -> location -> object**
  - **Hierarchy driven by need for efficiency - elegance was sacrificed!**
- **Most common routing dimensions were lat-long**
  - **Proximity creates "interest"**
- **Radio routing dimension was frequency-based**
  - **DDM efficiency required pre-definition of all frequencies to be simulated**
  - **Each Federate needed this list of frequencies to determine routing**
- **Some routing spaces based on simulation mechanics**
  - **E.g., Dynamic Terrain Federate used separate routing space to get new subscribers up-to-date without flooding everyone else with unneeded data**

STOW Routing Spaces (Concluded)

- **Routing definitions required extensive hand-tailoring to achieve needed efficiencies.**
  - Geographic routing cells tailored to scenario would have failed if actual movements different from expected; dynamic cell assignments would add flexibility.
  - Adjusted after each test based on actual traffic levels and host impacts
  - Needs more automation--this tailoring impractical for general use
- **Routing spaces couldn't always help**
  - Aggregate objects were so geographically concentrated, and range of interest so broad, that subscribers generally got all of it.
  - Interest in radar emissions did not fit cleanly into either a geographic or frequency model--we ended up with one routing cell for all emissions data.

STOW FEDEP Lessons Learned

- **The infrastructure (rti-s and network) worked well - no major failures**

- **Infrastructure came together too late--delayed and disrupted application testing**

- **Prototype implementation--quite fragile**

- **We *needed* this solution; STOW *did* have too much data for a "DIS-like" broadcast solution**

  - **Actual (measured) ACTD data rates indicate that without DDM, traffic levels would have killed the exercise by overrunning WAN and LAN capacity and choking all simulation hosts.**

  - **Routing space (interest management) implementation did the job, but...**

  - **For routine use, need more automation and more runtime flexibility**

  - **Major increases in scale will require additional technology**

STOW FEDEP Lessons Learned (concluded)

- **STOW needed to push the performance envelope to achieve its overall goals**

- **This required a tailored RTI implementation that matched STOW's requirements closely; fortunately the DARPA-DMSO collaboration enabled this.**

Very large Federations with ambitious goals may require similar specialized support and should not be discouraged.

Distributed Exercise Monitoring (DEM)

- **Four functions**
  - **Host-level monitoring**
  - **Network monitoring**
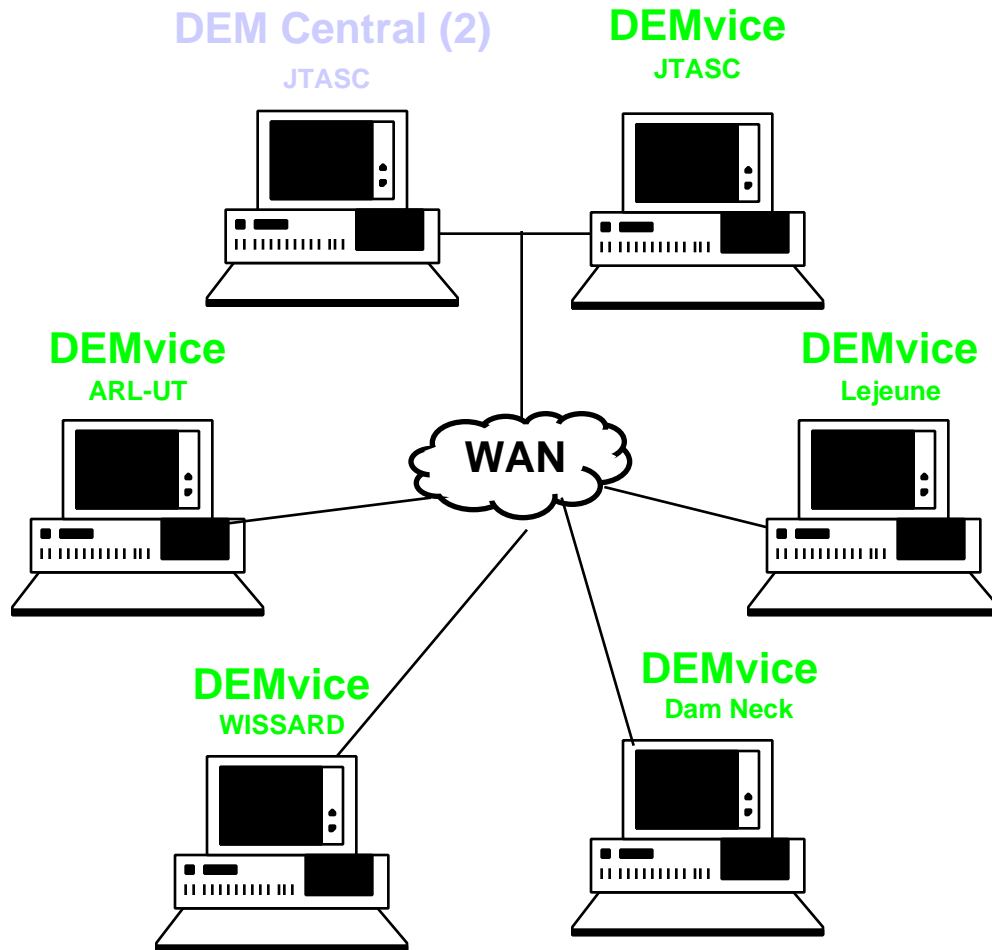 - **RTI monitoring**
  - **Exercise control through access to Federation management services [Not used by STOW.]**
    - **STOW needed to be able to perform pause/resume and save/restore on groups of Federates, not on the whole Federation.**
    - **We added interactions to support this need**

DEM STOW Configuration

DEM Central (2)
JTASC

DEMvice
JTASC

DEMvice
ARL-UT

DEMvice
Lejeune

WAN

DEMvice
WISSARD

DEMvice
Dam Neck

DEM Central:

- Located at Tech Control Center
- Monitors all RTI MOM Channels
- Provides HLA Exercise Control
- Processes alarms from DEMvices
- Logs exercise statistics
- Monitors WAN connectivity
- Able to query DEMvice data bases
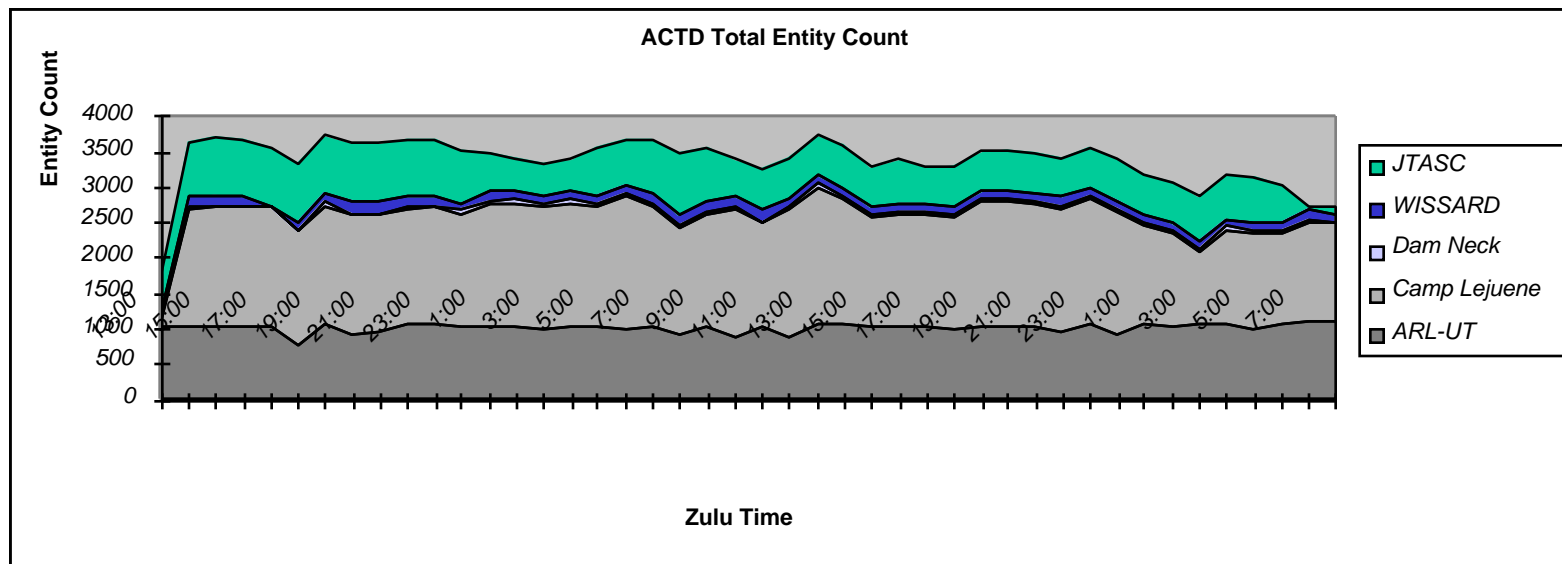- Monitors LAN ethernet switches

DEMvices:

- Located at each site
- Host network interface monitoring:
  Packets in/out, Errors in/out,
  Collisions
- Workstation monitoring:
  CPU utilization, SAF frame rate
- Monitors WAN Latency
- Monitors local RTI MOM Channel
- Alarms for out-of-tolerance conditions
- Logs local LAN statistics
- Forwards alarms to DEM Central
- Services DEM Central data requests

DEM RTI Monitoring

- **DEM monitors HLA RTI data through MOM (Management Object Model)**
    - **Number of objects by class**
    - **Number of federates**
    - **Types of Federate (ArmySAF, NavySAF, etc.)**
    - **Number of updates by transport mechanism**
    - **Bundling effectiveness and bundled packet size**
    - **State Consistent NAK packets**
    - **Federate and host names**

MOM Data: Entity Counts

- **Entity count was the most requested piece of DEM data**
  - **Number of federates reporting was also important**
- **Maximum entities just over 3700 during ACTD.**
  - **Lejeune (47%), ARL (30%), JTASC (19%), WISSARD (3%), Dam Neck (1%)**

ACTD Total Entity Count

Legend: JTASC, WISSARD, Dam Neck, Camp Lejuene, ARL-UT

Y-axis: Entity Count (0, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000)

X-axis: Zulu Time (15:00, 17:00, 19:00, 21:00, 23:00, 1:00, 3:00, 5:00, 7:00, 9:00, 11:00, 13:00, 15:00, 17:00, 19:00, 21:00, 23:00, 1:00, 3:00, 5:00, 7:00)

Other MOM Data

- **Maximum Object count - Just under 8000**
    - **Entity State (47%), Transmitter (38%), Aggregate State (15%)**
- **Maximum of 300 Federates**
    - **Marine SAF (39%), Army SAF (19%), Air SAF (18%), Navy SAF (13%), ModSAF (6%), Non SAF (5%)**
- **Federates subscribed to an average of 200 multicast groups and published to an average of 8 multicast groups.**

ACTD Total Objects by Type

	Legend
☐	Entity State
■	Transmitter
■	Stealth State
■	Environmental
■	Mine Field
☐	Mines
■	Aggregate State
■	Gridded Field

Y-axis: 0, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000

X-axis (Zulu Time): 17:00, 19:00, 21:00, 23:00, 1:00, 3:00, 5:00, 7:00, 9:00, 11:00, 13:00, 15:00, 17:00, 19:00, 21:00, 23:00, 1:00, 3:00, 5:00, 7:00

Zulu Time